

Far Infrared Spectroscopy of YSOs and Molecular Outflows

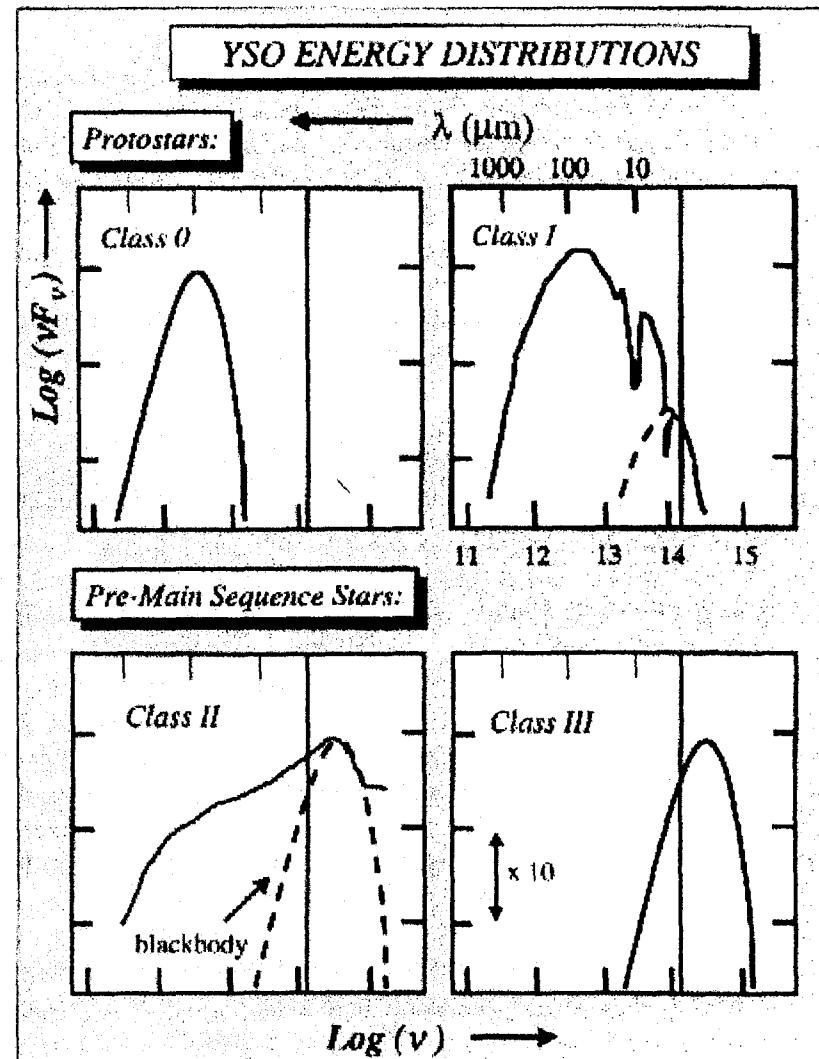
Alberto Noriega-Crespo (SIRTF Science Center)

Review talk based on work already approved & published.

“ISO Spectroscopy of the HH 7-11 Flow and its Redshifted Counterpart”

by S. Molinari, A.Noriega-Crespo (SSC-IPAC) et al. ApJ, 538, 698 (2000)

- Class 0 & I: SEDs which peak in the sub-mm or the FIR. SED dominated by cold dust.
- Class II -III: SEDs which peak in the optical and NIR. SED with a stronger contribution from the stellar photosphere.

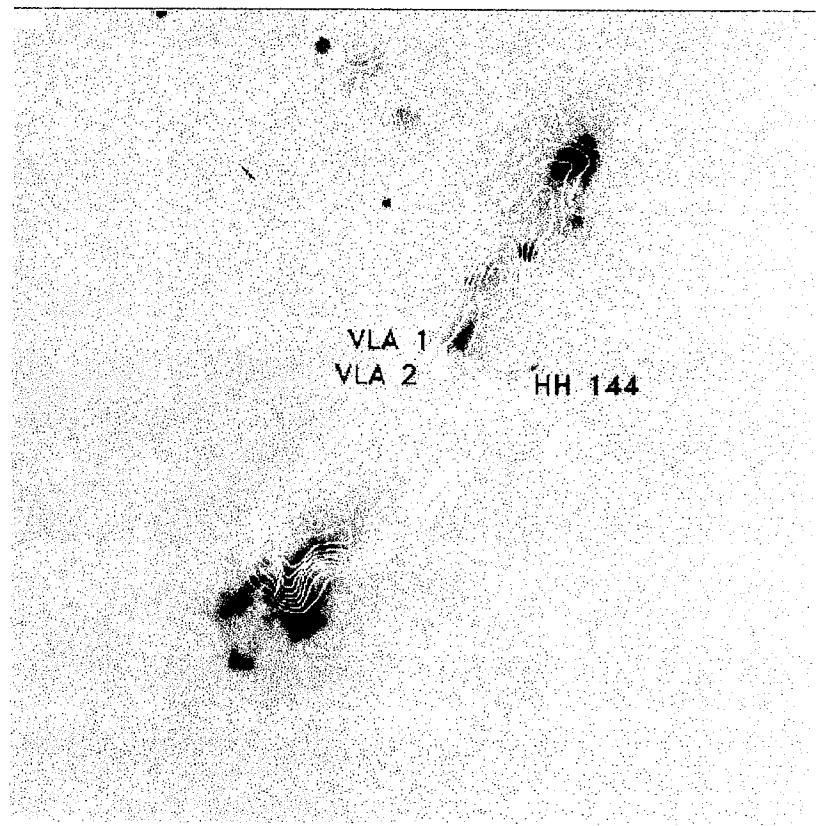


From Lada 1999 in The Origin of Stars and Planetary Systems.

Figure 11. The empirical classification scheme for YSO spectral energy distributions. A critical line appears at a wavelength of $2.2 \mu\text{m}$ for fiducial reference in each panel. Class I and Class III sources have distributions whose widths are similar to single temperature blackbody functions. Class II and Class I sources display infrared excess which produces energy distributions which are broader than a single blackbody function.

The Herbig-Haro 1-2 Outflow as a Prototype/Archetype

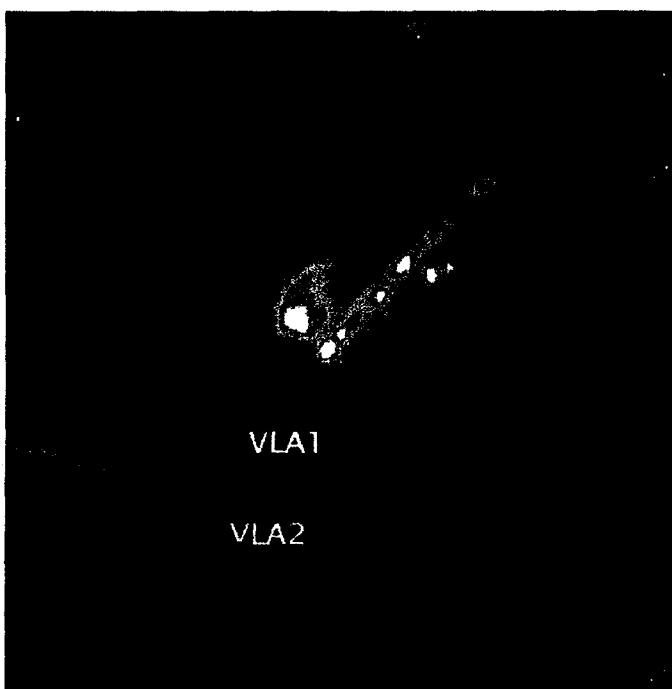
- ISOCAM Spectroscopic Observations using the CVF mode.
- Initial Goal: A better understanding of the spatial distribution of the shock excited emission.
- J-type & C-type shocks.
- HH 1-2 at 460pc in Orion; brightest optical outflow (FOV approx 2 arcminutes).
- *Moro-Martin et al. 1999, ApJ, 520, L111*



HH1-2



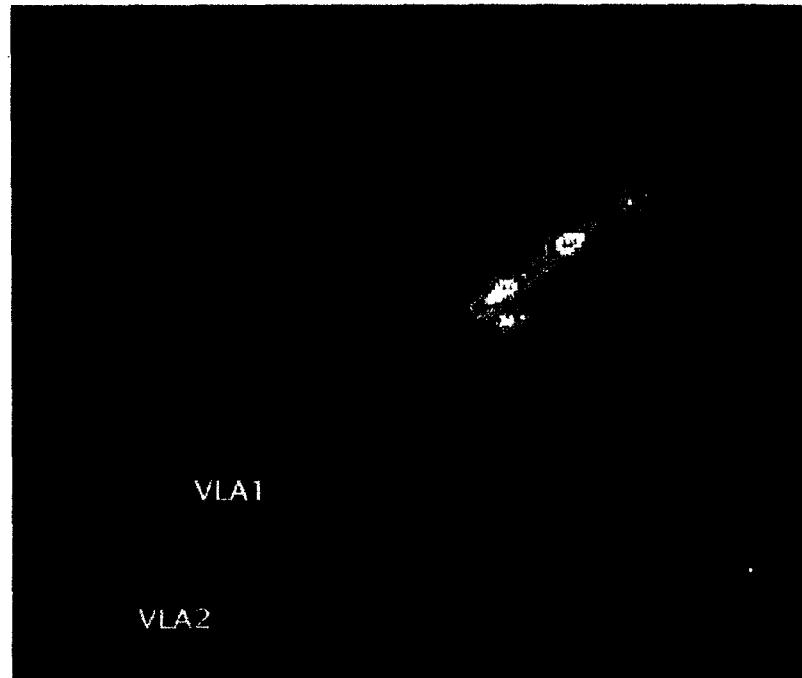
[FeII]
1.64um



VLA1

VLA2

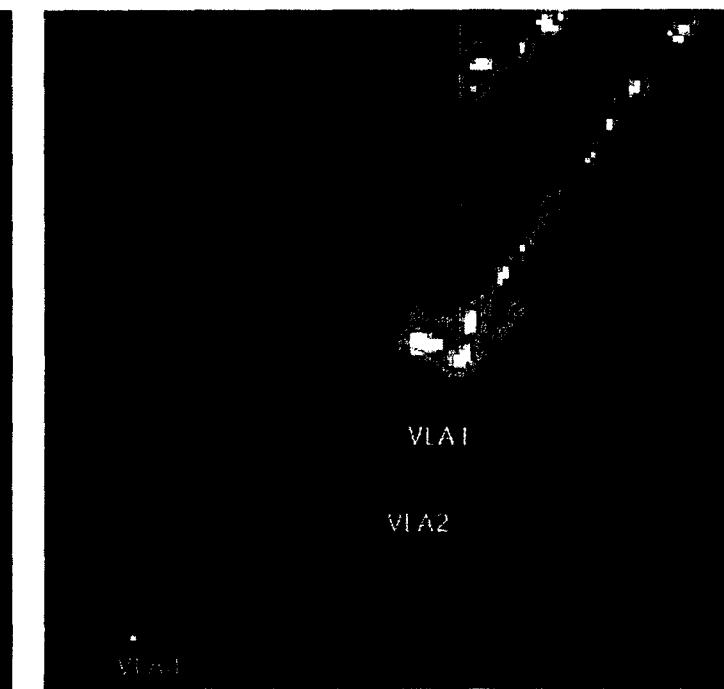
[SII]
0.7um



VLA1

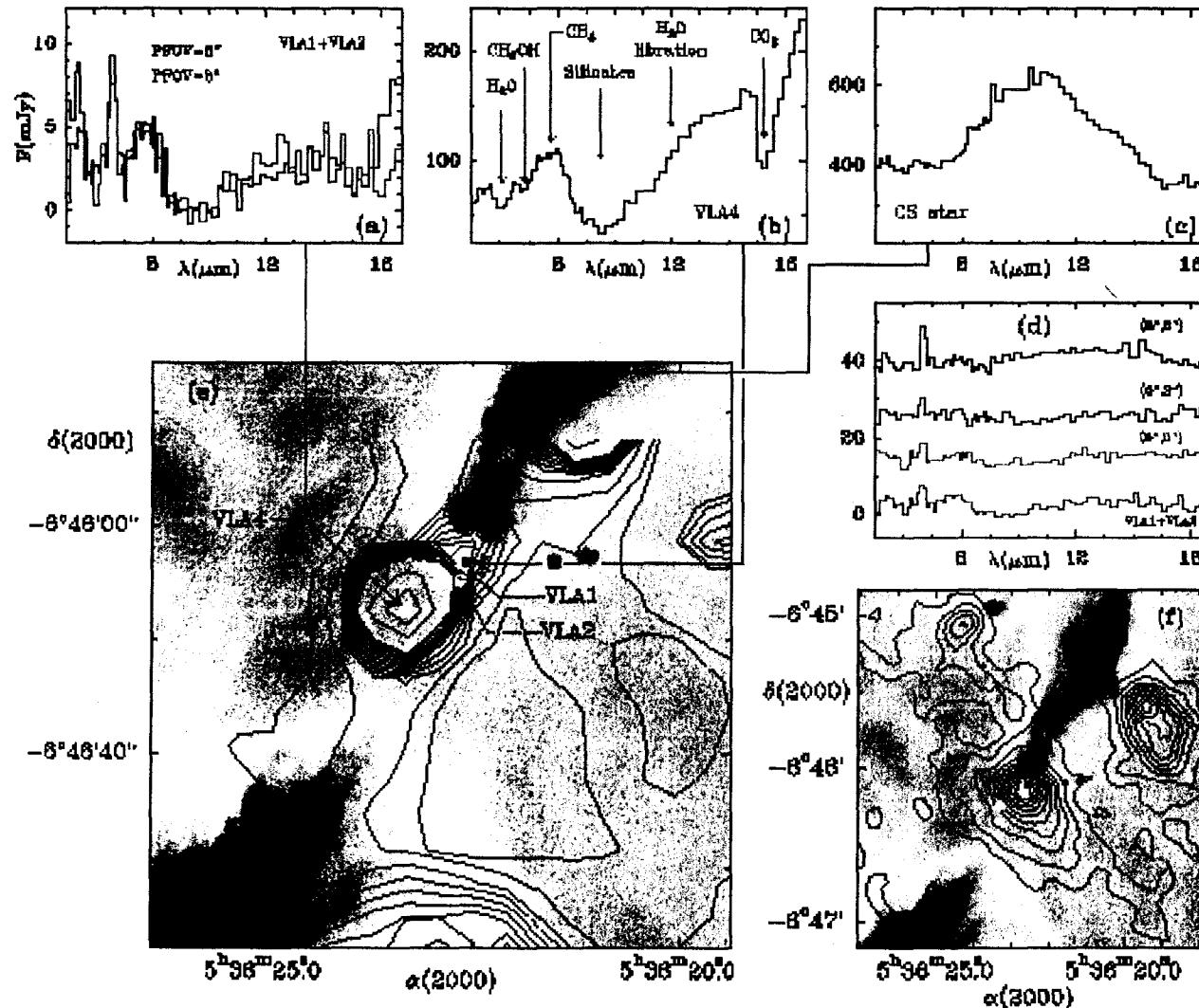
VLA2

H2
2.12um

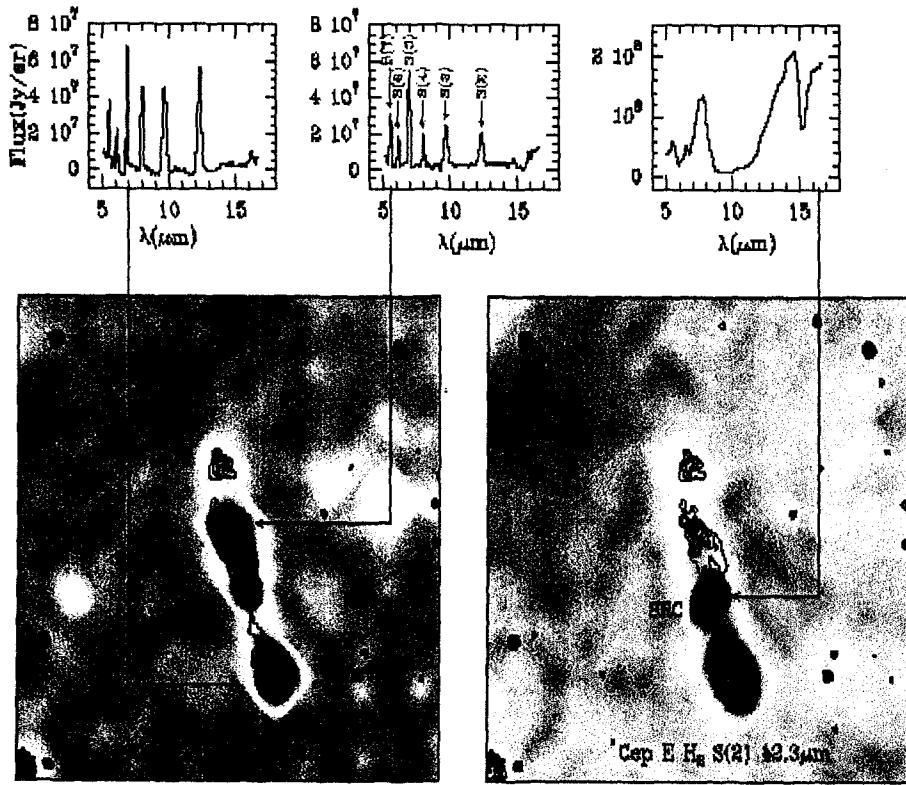


VLA1

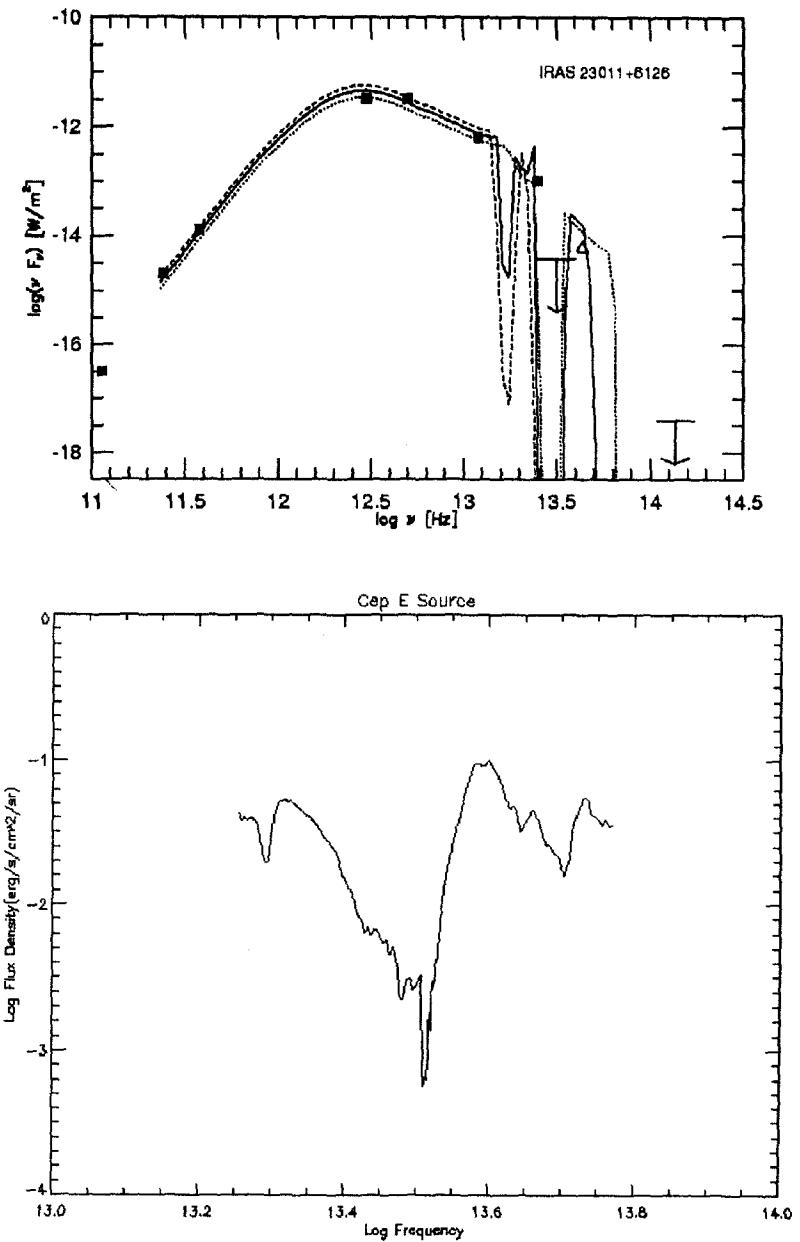
ISOCAM CVF Observations of the HH1-2 Outflow



At least 3 embedded sources in the region.
VLA 1, a class 0 source, the most obscured ($A_v=80-100$)



- **Cepheus E Outflow.** Discovered at radio wavelengths and the source in mms. Careful analysis shows the source in the IRAS bands .
- ISOCAM CVF at 6.9 and 9.6 μ m set upper limits (*Noriega-Crespo, Molinari & Garnavich 1998*).
- Complete CVF shows clearly the source.



- For several outflows, with presumably class 0 sources, “we see” the sources at mid-IR wavelengths.
- In principle it should be possible to detect these proto-stars from the ground (we are working on it).

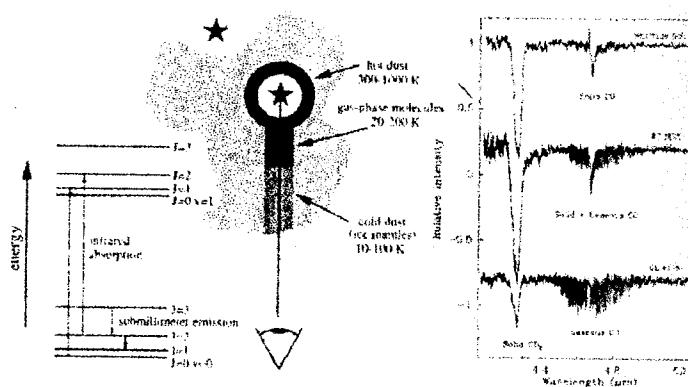


Figure 6. Left: Schematic illustration of infrared absorption line observations of gas and dust toward embedded or background sources. The infrared continuum is provided by the hot dust at 300–1000 K. Right: Normalized ISO-SWS spectra toward three massive young stellar objects embedded in dense molecular clouds. The strong, broad absorption at 4.27 μm is due to solid CO₂, whereas the characteristic ro-vibrational P- and R-branch structure at 4.1–4.9 μm indicates the presence of warm gaseous CO along the line of sight (van Dishoeck et al. 1998).

